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EVALUATING HOSPITAL EFFICIENCY ADJUSTING FOR QUALITY INDICATORS: AN APPLICATION TO PORTUGUESE NHS HOSPITALS

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Evaluating Hospital Efficiency Adjusting for Quality Indicators: an Application to Portuguese NHS Hospitals

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Abstract

The objective of this paper is to develop a methodology to incorporate measures of hospital quality in efficiency analysis, applied to Portuguese NHS hospitals, in order to assess whether there is a trade-off between efficiency and quality in Portuguese hospitals. We develop and compare two methodologies to compute DEA technical efficiency scores adjusted for output quality, for a sample of Portuguese NHS hospitals in 2009.

When DEA efficiency scores are adjusted for output quality, the decision making units that lie on the technical efficiency frontier remain largely unaltered, even if a great weight is given to quality indicators over quantity indicators of output. Nevertheless, we find that outside of the frontier adjusting for quality does have an impact in efficiency scores.

We conclude that the empirical evidence is not sufficient to identify a clear trade-off between efficiency and quality in the hospitals under review, implying the possibility that efficiency gains may be achieved without a significant sacrifice of service quality. Nevertheless, there is enough evidence to conclude that analyzing hospital efficiency without consideration of differences in quality of service will generate biased results. When perceived quality is brought to the analysis, the gap between efficient and inefficient units tends to widen.

Keywords: Hospital efficiency, Hospital quality, Data Envelopment Analysis

JEL Classification: I - I-1 - I-18

1 Introduction

In an era of resource constraints, there is an increasing interest of hospital managers and health administration authorities in designing methods to evaluate hospital performance. The ability to rank efficient hospitals over their inefficient counterparts provides a benchmark for hospital managers to discover and reduce potential inefficiencies, and provides health administration authorities with measures that may be used to reward good managers. With this increasing interest in hospital performance, a vast academic literature has emerged on measures and comparisons of hospital efficiency, where quantitative measures of inputs are compared with quantitative measures of outputs, usually using Data Envelopment Analysis (DEA) or Stochastic Frontier Analysis (SFA).

However, many have expressed concerns that this increased focus on efficiency may induce managers to neglect service quality. Since health outcomes depend on the quantity, but also on the quality, of the healthcare services provided, it is possible that a hospital may increase its efficiency ranking with a deterioration of health outcomes, if there is an efficiency/quality trade-off.

The objective of this paper is to develop a methodology to incorporate measures of hospital quality in efficiency analysis, applied to Portuguese NHS hospitals, in order to assess whether there is a trade-off between efficiency and quality in Portuguese hospitals.

We develop and compare two methodologies to compute DEA technical efficiency scores adjusted for output quality, for a sample of Portuguese NHS hospitals in 2009. The quality of Portuguese hospital healthcare services is measured by two types of indicators. The first set of indicators is based on data from a 2009 survey of patients, designed by the ACSS (Administração Central do Sistema de Saúde) and Universidade Nova, whose main goal is to provide an independent system of regular evaluation of patient satisfaction and of hospital quality, as perceived by users of Portuguese NHS hospitals, the “Sistema de Avaliação da Qualidade Apercebida e da Satisfação dos Utentes dos Hospitais EPE e SPA 2009”. The second set of indicators is related to the timeliness of care, as measured by the waiting lists for elective surgery.

The rest of this paper is organized as follows. In section 2 we provide a brief review of the relevant literature. Section 3 describes the data used in this paper, while the methodology is

presented in section 4. Our results are in section 5. Section 6 presents is dedicated to a robustness analysis. Section 7 concludes.

2. Literature review

There is a vast literature on measurement of efficiency and productivity of health care organizations. Hollingsworth (2008) provides a review of 317 published papers on frontier efficiency measurement in healthcare, concluding that even though there is an increasing use of parametric techniques, such as stochastic frontier analysis, around three quarters of the papers use nonparametric data envelopment analysis. Studies of hospital efficiency are the most common (52% of the papers reviewed in Hollingsworth, 2008).

Hollingsworth (2008) does not cover any paper studying the efficiency of Portuguese hospitals, even though it includes 3 papers on the efficiency of OECD health systems, where Portugal is one of the countries mentioned (Afonso and St Aubyn 2005, Bhat 2005, Retzlaff-Roberts et. al 2004). Nevertheless, there are several studies on the efficiency and productivity of Portuguese hospitals.

Barros et. al (2007) use the directional distance function and the Luenberger productivity indicator to generate a productivity indicator that is decomposed into the usual constituents of productivity growth: technological change and efficiency change. They conclude that Portuguese hospitals experienced very weak productivity growth and low incidence of technological change in the period from 1997 to 2004. Harfouche (2008) used DEA to evaluate the impact of changes in the hospital management model in the technical efficiency level, having concluded that the new public-enterprise hospitals were more efficient than the traditionally managed hospitals. Rego et. al (2010) use DEA to investigate the efficiency of a set of public Portuguese hospitals. They compare the performance of 21 state-owned hospital enterprises with 38 traditional public administration sector hospitals, to conclude that the introduction of market processes and changes in organizational structure – such as managerial autonomy and corporatization of public hospitals – have had a positive impact on Portuguese public hospitals. Simões and Marques (2011) assess the performance of Portuguese hospitals and particularly the contribution of the congestion effect, using DEA and a double-bootstrap

procedure to take into account the influence of operational environment on efficiency, to conclude that there were significant levels of inefficiency in 68 major Portuguese hospitals for the year 2005 and more than half of them were found to be congested.

However, none of these papers take into consideration that output quality may vary across hospitals, and that traditional quantitative measures of output do not capture all the relevant dimensions of efficiency. The importance of incorporating quality measures in DEA hospital efficiency analyzes has been recognized in a few recent papers. Clement et al. (2008) include multiple quality indicators as outputs in a DEA efficiency study of 667 American hospitals, concluding that lower technical efficiency is associated with poorer risk-adjusted quality outcomes in the study hospitals. Nayar and Ozcan (2008), use DEA and a sample of Virginia hospitals to examine performance measures of quality and relate them to technical efficiency, having concluded that some of the technically efficient hospitals were performing well as far as quality measures were concerned. Valdmanis et al. (2008) apply DEA to input and output data from 1377 urban hospitals, include nurse-sensitive measures of quality, and conclude that higher quality in some dimensions of care need not be achieved as a result of higher costs or through reduced access to healthcare. More recently, Navarro-Espigares and Torres (2011), analyse the evolution of efficiency and quality in Andalusian Hospitals during the years 1997–2004 and rule out the existence of an efficiency–quality trade-off.

The international evidence seems to link poor quality outcomes to higher cost, which is confirmed by the Portuguese evidence presented in Gouveia et al (2006) using mortality as proxy for quality. However, there is no study where the quality proxies have a direct relationship with the quantitative output measures. This is the main contribution of this paper. Our paper is the first one, to our knowledge, to apply quality-adjusted DEA efficiency measures to Portuguese hospitals, allowing us to examine whether an efficiency / quality trade-off exists in the Portuguese hospital sector. Furthermore, our analysis allows us to investigate whether abstracting from a qualitatively oriented approach produces biased results.

3. Data

3.1 Data Sources

Since the objective of this paper is to analyze whether there is a trade-off between efficiency

and perceived quality/patient satisfaction the needed data is extracted from different sources.

We use cross-sectional data from a sample of 37 Portuguese hospitals for 2009. Although data were available also for oncology and psychiatric hospitals, they were not included given the highly specialized nature of these units. The choice of this particular sample rested on data availability for physical inputs and outputs. The sample is quite representative, since the hospitals in it were responsible for a very high share of the total production of Portuguese hospitals in the previous year (e.g., the hospitals in the sample were responsible for 80% of the inpatient visits, of emergency episodes and of outpatient visits and 95% of the surgery interventions).

To measure the impact of perceived quality/patient satisfaction in the DEA efficiency scores we resort to the report produced by the Assessment System of the Perceived Quality and Patient Satisfaction (Sistema de Avaliação da Qualidade Apercebida e da Satisfação do Utente dos Hospitais EPE e SPA - 2009)¹. This enquiry, conducted by ISEGI-UNL, is based on data collected from phone interviews from July 2009 until March 2010 on a sample of 28669 individuals. As a result four satisfaction indices were created covering inpatient visits, outpatient visits, emergency episodes and ambulatory surgery interventions. The methodology employed is compatible with the American Customer Satisfaction Index (ACSI).

Quality is also measured by the timeliness of care, as measured by the waiting lists for elective surgery. The variable used is the number of patients, LIC, registered in the waiting list of each hospital. The data is extracted from the report of the scheduled surgical activity (Relatório da Actividade em Cirurgia Programada ²).

3.2 DEA input measures

Following several papers on hospital efficiency (see Hollingsworth 2008), we use physical

¹ More information at Administração Central do Sistema de Saúde, Inquéritos de satisfação <http://www.acss.min-saude.pt/Direc%C3%A7%C3%B5es/Unidades/Gest%C3%A3o/RiscoeAuditoriaSNS/Inqu%C3%A9ritosdeSatisfa%C3%A7%C3%A3o/tabid/455/language/pt-PT/Default.aspx> (accessed in May 5, 2011)

² Portuguese Health Ministry, “Relatório da Actividade em Cirurgia Programada, 2009”, <http://www.min-saude.pt/NR/rdonlyres/0123250E-B4DE-4AC7-BB25-082701E40F3D/0/UCGICTL20100713RelatorioTP2009VE1.pdf> (accessed in May 5, 2011)

inputs data as a proxy for the labor and capital factor. The labor proxies are: (i) Doctors – number of doctors, (ii) Nurses – number of nurses and, (iii) OtherStaff – remaining staff at the units’ service. As a proxy for capital we use the number of beds (Beds). Alternatively, in the robustness analysis, we also look at total costs, in million euros, as described in the hospitals’ financial accounts.

3.3 DEA output measures

The output measures are comprised by inpatient visits, outpatient visits, emergency episodes, and surgery interventions (ambulatory plus non-ambulatory).

The interesting element of using this set of physical outputs is that we can get a direct correspondence of most of the outputs with the perceived quality/patient satisfaction indices. Table 1 provides the data descriptive statistics.

Inpatient visits are very heterogeneous; therefore, we adjust this variable by weighting it with a case-mix index (CMI). Since the latest CMI published by the System of Patient Classification in DRG is for 2006,³ we use a length of stay base case-mix index for 2009. To construct this index, we follow Herr (2008, pp. 1062-1063) by using the length of each inpatient visit as a proxy for the complexity of each case.

This index uses the length of stay as a proxy to the resource use associated with each diagnosis. The underlying idea is that hospitals with a higher incidence of diagnosis with high treatment duration have a higher case-mix index. To do so, the mean length of stay (los) of each main diagnosis $m = 1, \dots, M$ over all Portuguese hospitals $i = 1, \dots, N$ is computed:

$$\text{los}_m = \frac{1}{N} \sum_{i=1}^N \frac{\text{days}_{mi}}{\text{cases}_{mi}}. \quad (1)$$

Then, using equation (1), the *los* of each diagnosis is compared with the overall average *los* of all diagnoses:

$$\pi_m = \frac{\text{los}_m}{\text{los}_P}, \quad (2)$$

³ Administração Central do Sistema de Saúde, “Informação de Retorno do Sistema de Classificação de Doentes em Grupos de Diagnósticos Homogéneos (GDH) 2006” http://www.acss.min-saude.pt/Portals/0/Nacional_RR2006.pdf.

where $\text{los}_p = \frac{1}{M} \sum_{m=1}^M \text{los}_m$ with $\frac{1}{M} \sum_{m=1}^M \pi_m = 1$. Therefore, π_m can be used as a proxy for the complexity of diagnosis m , and with it an alternative case-mix index can be calculated.

Let us denote by $LCMI_i$ the length based case mix index of DMU i , such that using equation (2) we have:

$$LCMI_i = \sum_{m=1}^M \pi_m \frac{\text{cases}_{mi}}{\text{cases}_i}, \quad (3)$$

where $\text{cases}_i = \sum_{m=1}^M \text{cases}_{mi}$. Additionally, we normalize this index by dividing equation (3) by the average value of the index:

$$NLCMI_i = \frac{LCMI_i}{\frac{1}{N} \sum_{i=1}^N LCMI_i}. \quad (4)$$

The data for inpatient visits came from the official registry of inpatient episodes and outpatient surgeries in Portuguese NHS hospitals, held by the Central Administration of the Health System (ACSS), for 2009. These records are coded according to the international classification of diseases ICD-9-CM and also classified through the Portuguese DRG system, which is based on the version 21.0 of the AP-DRG grouper. The dataset included 930878 episodes, which were classified under 26 different diagnoses.

In the construction of the 2009 LCMI, to overcome the issue of missing values, it was assumed that each hospital that is in the composition of the hospital centre is representative of it. Given the specificity of certain units, such as oncology centers, they were removed for the sample. Once the index obtained in equation (4) is calculated, the risk-adjusted inpatient admissions can be calculated by its product with the effective production.

Table 1 - Data descriptive statistics

	Mean	Std. Dev.	Min	Max
Inputs				
Doctors	405,94	317,41	103	1316
Nurses	778,28	521,90	191	2131
Otherstaff	1139,47	811,70	251	3548
Beds	534,36	317,94	124	1456
Total Costs	132,35	98,50	28,14	417,52

Outputs				
Inpat	21164,19	11331,06	5208	50128
Outpat	247313,54	178228,78	66194	787716
Emergency	148651,57	55629,51	67161	286430
Surgery				
Ambulatory	5772,59	4207,09	922	18966
Non-ambulatory	8871,03	6539,65	0	27734
Quality Indicators				
PQ - Inpat	80,77	3,01	72,20	87,00
PQ – Outpat	77,17	2,67	72,40	82,30
PQ – Emergency	70,86	3,57	62,10	77,20
PQ – Ambulatory	83,46	2,50	76,70	89,60
LIC	4005,38	2766,85	767	11799

4. Methodology

In this study we follow the majority of the vast academic literature on measures and comparisons of hospital efficiency, and use Data Envelopment Analysis (DEA) to compare quantitative measures of inputs with quantitative measures of outputs (see section 2). DEA is a non-stochastic, nonparametric estimation method that determines a “best-practice” frontier given the available data. Hospital efficiency scores are then computed with respect to this reference.

4.1 Patient Perceived Satisfaction

Here, we focus on radial output-oriented efficiency measures, i.e., given a fixed vector of inputs what is the maximal proportional expansion achievable of the vector of outputs (see Hollingsworth 2008 for a more complete description of distance function based efficiency measures). The lower bound of these efficiency scores is 1.00, which indicates the decision

making unit (DMU) is output-based efficient, and a score greater than the unity points towards efficiency improvement opportunities. Our research interest focus on the emphasis given to the procedures taken by the hospital management towards improving patient satisfaction holding fixed the unit's resources. Therefore, we adopt an output orientation, i.e., what is the maximum expansion that hospitals can achieve holding inputs fixed,

In the description of the methodology, we follow the notation used by Ferrier et. al (2006). The production function is represented by the correspondence of the vectors of outputs $\mathbf{y} = (\mathbf{y}_1, \dots, \mathbf{y}_m)$ that can be produced by using the vectors of inputs $\mathbf{x} = (\mathbf{x}_1, \dots, \mathbf{x}_k)$ as follows:

$$P(\mathbf{x}|V) = \left\{ \mathbf{y}: \mathbf{y} \leq \mathbf{z} \cdot \mathbf{M}, \mathbf{z} \cdot \mathbf{K} \leq \mathbf{x}, \mathbf{z} \in \mathfrak{R}, \sum_{i=1}^n z_i = 1 \right\}, \quad (5)$$

where \mathbf{z} is the vector of weights that generate the convex combinations of inputs (where \mathbf{K} is a n -by- k matrix) and outputs (where \mathbf{M} is a n -by- m matrix). Under this formulation, the technology exhibits variable returns to scale (VRS), as imposed by the restriction on the summation of the elements of \mathbf{z} . Given this characterization of the productive technology, the Farrell output based efficiency measure can be computed by solving the following linear programming problem for each DMU, where the scalar $\theta (\geq 1)$ is the technical efficiency score:

$$\begin{aligned} & \max_{\mathbf{z}, \theta} \theta \\ & s. t. \quad \theta \cdot \mathbf{y} \leq \mathbf{z} \cdot \mathbf{M} \\ & \quad \mathbf{z} \cdot \mathbf{K} \leq \mathbf{x} \\ & \quad \mathbf{z} \in \mathfrak{R} \\ & \quad \sum_{i=1}^n z_i = 1 \end{aligned} \quad (6)$$

Given the purpose of our analysis, we define a perceived quality index (PQI) that allows us to adjust the quantitative output measures. The index is defined as follows:

$$PQI_{i,j} = \frac{PQ_{i,j}}{\overline{PQ_j}}, \quad (7)$$

where $PQI_{i,j}$ is the value of the index for DMU i and for output j , $PQ_{i,j}$ is the perceived quality indicator designed by ACSS and ISEGI-UNL for DMU i and for output j and $\overline{PQ_j}$ is the average value of the indicator for output j in our sample. Clearly, a value greater (lower) than one indicates the DMU i is providing a service with perceived quality standards above (below) the average of the DMUs included in the analysis. Once the index is obtained, it is

used to adjust the quantitative output measures. This adjustment is performed simply by multiplying the PQI by the quantitative output measures, such that those DMU that provide a service with quality standards above average are producing more quality adjusted outputs and thus obtain higher efficiency scores.

The objective is to obtain a set of efficiency scores that does not take into account the perceived quality indicators (baseline - BL scores) and another one that does (perceived quality adjusted – PQA scores). Then, we compare the two sets to determine the effect of the perceived quality adjustment. In order to do so, we conduct a Wilcoxon matched-pairs test. This is a nonparametric test that analyzes the relation between two paired groups. It is used to test whether a treatment has an effect in the population, it does so by looking at the median difference given the set of differences shown by these two groups.

4.2 Timeliness of Care

In addition to the perceived quality indicators, quality is also assessed by timeliness of care, as measured by the waiting lists for elective surgery. Like the analysis done in the previous subsection, the answer we try to answer is whether an efficiency analysis provides a complete picture absent of our chosen qualitative indicators.

Methodologically, this variable is treated as an undesirable output. The fundamental idea is that when producing desirable outputs (such as inpatients visits), the unit also produces waiting lists. Shorter waiting lists could be achieved by shifting resources towards the production of more surgeries, but that would imply producing fewer quantities of some desirable outputs. Thus, this implies a trade-off between producing more of the desirable outputs and less of the undesirable output.

To see whether there is a trade-off between efficiency and quality (as measured by the timeliness of care) it is crucial to find a measure of output congestion, i.e., how much efficiency is reduced by ‘producing’ this undesirable output. To do so we follow the methodology employed by Ferrier et. al (2006) and Clement et al. (2008) that has its roots in Färe et al.(1994). This approach starts by taking all outputs as desirable using the assumption

of strong disposability of all outputs, and then this assumption is replaced by the one of weak disposability of the undesirable output⁴.

Under the strong output disposability assumption, the production technology is described in a similar way as it was in expression (5) with the exception of an added output, as shown in expression (8).

$$P(x|V, S) = \left\{ \mathbf{y}: \mathbf{y} \leq \mathbf{z} \cdot \mathbf{M}, \mathbf{z} \cdot \mathbf{K} \leq \mathbf{x}, \mathbf{z} \in \mathfrak{R}, \sum_{i=1}^n z_i = 1 \right\}, \quad (8)$$

Replacing this assumption with the one of weak disposability of the undesirable output leads to the change in the description of the production technology shown in expression (9).

$$P(x|V, S/W) = \{(\mathbf{y}^S, \mathbf{y}^W): \mathbf{y}^S \leq \mathbf{z} \cdot \mathbf{M}^S, \mathbf{y}^W = \mu \cdot \mathbf{z} \cdot \mathbf{M}^W, \mathbf{z} \cdot \mathbf{K} \leq \mathbf{x}, \mathbf{z} \in \mathfrak{R}, \\ 0 \leq \mu \leq 1, \sum_{i=1}^n z_i = 1\} \quad (9)$$

The congestion score is obtained by the ratio of the technical efficiency scores obtained under the strong disposability assumption and the weak one, as shown in equation (10).

$$C_0(x, y|V) = \frac{\theta^{S^*}}{\theta^{S/W^*}} \geq 1, \quad (10)$$

where θ^{S^*} and θ^{S/W^*} are found by solving the linear and non-linear programming problems outlined in expressions (11) and (12), respectively.

$$\begin{aligned} & \max_{\mathbf{z}, \theta^{S^*}} \theta^{S^*} \\ & s. t. \\ & \theta^{S^*} \cdot \mathbf{y} \leq \mathbf{z} \cdot \mathbf{M} \\ & \mathbf{z} \cdot \mathbf{K} \leq \mathbf{x} \\ & \mathbf{z} \in \mathfrak{R} \\ & \sum_{i=1}^n z_i = 1 \end{aligned} \quad (11)$$

⁴ For a complete explanation on the different disposability assumptions see Färe et al. (1989).

$$\begin{aligned}
& \max_{\mathbf{z}, \mu, \theta^{S/W^*}} \theta^{S/W^*} \\
& s. t. \\
& \theta^{S/W^*} \cdot \mathbf{y}^S \leq \mathbf{z} \cdot \mathbf{M}^S \\
& \theta^{S/W^*} \cdot \mathbf{y}^W = \mu \cdot \mathbf{z} \cdot \mathbf{M}^W \\
& \mathbf{z} \cdot \mathbf{K} \leq \mathbf{x} \\
& 0 \leq \mu \leq 1 \\
& \mathbf{z} \in \mathfrak{R} \\
& \sum_{i=1}^n z_i = 1
\end{aligned} \tag{12}$$

Once this congestion measure is obtained, we can go to the baseline model described without any reference to quality measures and ask whether those units that are deemed efficient present higher congestion scores than the ones lying below the frontier. If this were to happen, then the higher efficiency scores could be explained by differences in the congestion scores, i.e., efficient units are only so at the cost of longer waiting lists. To see whether this is a valid assumption, a Wilcoxon rank sum and a Kruskal-Wallis test are performed.

To complement the congestion analysis, we calculate perceived quality adjusted congestion scores to answer whether the efficient units identified in our baseline scenario operate under significantly different congestion levels. This new measure aims to capture the changes produced by focusing in a quantity/quality combined accountability of output. To do so, we perform again a Wilcoxon rank sum and a Kruskal-Wallis test.

5. Results

5.1 Patient Perceived Satisfaction

Table 2 presents the output oriented efficiency scores⁵ descriptive statistics.

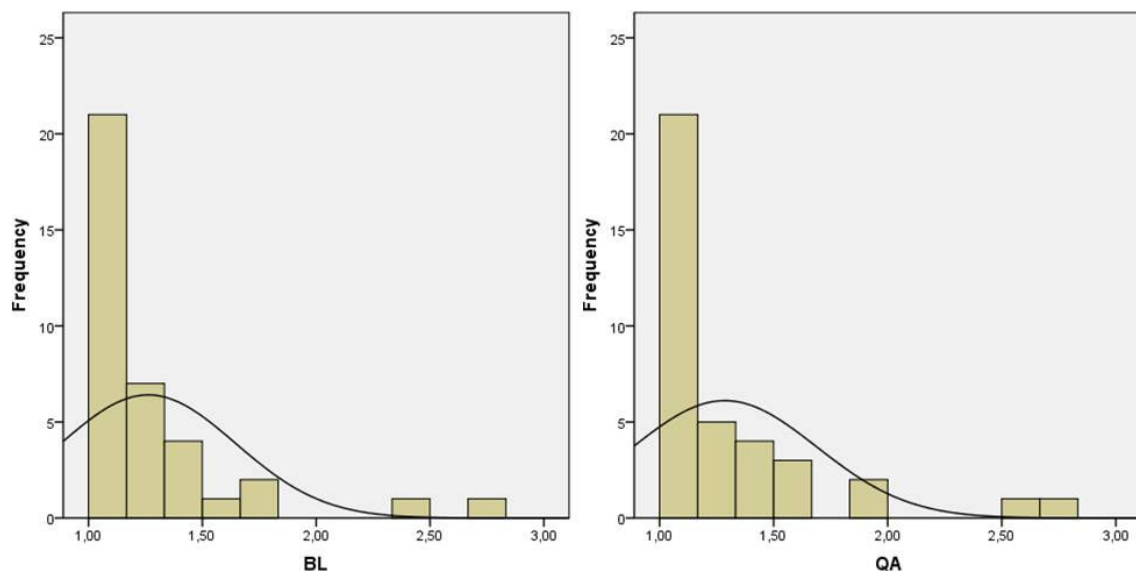
The high percentage of units in the frontier reflects the limited number of observations and the broad definition of the technology. Nevertheless, under this specification, the perceived quality adjustment is significant at a 1% level of significance.

Table 2 - Results descriptive statistics

Model	Frontier (%)	Mean Effic. Score	Std. Dev.	Min	Max	Skewness	p-value*
BL	48,6	1,084355	0,112904	1	1,420455	1,420455	0,001
PQA	43,2	1,105519	0,134322	1	1,447178	1,447178	

*asymptotic (1-tailed) p-value obtained for the Wilcoxon matched-pairs test.

Figure 1 - Results distribution



The results shown in the previous table demonstrate that the efficient units remain in the

⁵ Choosing an input orientation would not change significantly the results.

‘best-practice’ frontier regardless the treatment given to perceived quality indicators. This could happen for two reasons: (i) the perceived quality indicators do not provide useful information with respect differentiating the decision making units; or (ii) the most efficient units are also the ones that operate under the highest perceived quality standards. The empirical evidence, as given by the results of the one-tailed Wilcoxon matched-pairs test, seems to favor the second alternative. If alternative (i) were to stand against our estimation results, then the underlying null hypothesis of the one-tailed Wilcoxon matched-pairs test could not be rejected at the usual significance levels, which is not the case. Although we see some significant shifts in the rankings of the several units, the most pronounced effect is the increase in the skewness of the results’ distribution (see figure 1). This indicates that the perceived quality effect leads to a decrease in the efficiency scores of the units located below the frontier. Therefore, we find evidence that not taking quality into account leads, in general, to an overestimation of the efficiency scores of inefficient hospitals. Some exceptions do exist, though.

The results presented above show that the empirical evidence is not sufficient to identify a clear trade-off between efficiency and quality in the hospitals under review, implying the possibility that efficiency gains may achieved without a significant sacrifice of service quality. Nevertheless, there is enough evidence to conclude that analyzing hospital efficiency without consideration of differences in quality of service will generate biased results. When perceived quality is brought to the analysis, the gap between efficient and inefficient units tends to widen, as confirmed by the one-tailed Wilcoxon matched pairs test.

5.2 Timeliness of Care

Table 3- Congestion analysis

Model	Mean Congestion	Kruskal-Wallis*	Wilcoxon rank sum*
Efficient	1,06409		
Inefficient	1,06674	0,60	0,60

* asymptotic (2-tailed) p-values.

Although the congestion scores are slightly lower for the baseline scenario efficient units, the results in table 3 show that at the usual levels of significance there is not enough evidence to

conclude that there is a difference among the two groups of hospitals. Therefore, the loss of efficiency due to the undesirable output does not explain the difference in efficiency scores, i.e., there does not seem also to exist here a trade-off between efficiency and quality.

The results in table 4 are in line with the ones shown in the previous congestion analysis. Again, the empirical evidence does not support a efficiency-quality trade-off.

Table 4 - Perceived quality adjusted congestion analysis

Model	Mean Congestion	Kruskal-Wallis*	Wilcoxon rank sum*
Efficient	1,074557		
Inefficient	1,068635	0,24	0,24

* asymptotic (2-tailed) p-values.

6. Robustness

The high number of units deemed efficient, in the specification chosen previously, recommend some caution in their interpretation. The reduced dimension of the sample, unfortunately, does not allow for a higher degree of freedom. Nevertheless, a specification with physical inputs presents a more complete description of the technology and, therefore is the main focus of our analysis.

To check the robustness of our results, we look at total costs as a measure of input. The perceived quality adjustment produces a decrease in five percentage points in the percentage of efficient units, and passes the Wilcoxon matched test at a level of 5% of significance, as we can see in table 5.

Table 5 - Results descriptive statistics

Model	Frontier (%)	Mean Effic. Score	Std. Dev.	Min	Max	Skewness	p-value*
BL	32,4	1,262159	0,383776	1	2,71739	2,321821	
PQA	27,0	1,285839	0,402496	1	2,673797	2,127823	0,01

*asymptotic (1-tailed) p-value obtained for the Wilcoxon matched-pairs test.

Again, we find that the most of the units deemed efficient in a purely quantitative specification remain so when the perceived quality indicators are taken into account. The same happens for the generalized decrease in the inefficient units technical efficiency scores. Therefore, we conclude that our findings are robust to the input specification.

We now turn our attention towards the congestion scores. Table 6 shows, once more, that there are only slight differences in the congestion scores of efficient and inefficient units. This can be confirmed by the non-parametric test results. As such, we conclude that the absence of a trade-off between efficiency and perceived quality is robust to the technology specification.

Table 6- Congestion analysis

Model	Mean Congestion	Kruskal-Wallis*	Wilcoxon rank sum*
Efficient	1,054741		
Inefficient	1,039262	0,4	0,4

* asymptotic (2-tailed) p-values.

The same is true for the perceived quality adjusted congestion analysis, as shown in table 7.

Table 7 - Perceived quality adjusted congestion analysis

Model	Mean Congestion	Kruskal-Wallis*	Wilcoxon rank sum*
Efficient	1,062614		
Inefficient	1,045533	0,26	0,26

* asymptotic (2-tailed) p-values.

7. Conclusions

The purpose of this paper is to answer two questions. The first one is whether a trade-off between efficiency and quality exist in the Portuguese NHS hospitals. The second one is whether DEA efficiency scores are biased when strictly quantitative outputs are considered.

To answer the first question, we use two types of indicators. The first set of indicators is

based on data from a 2009 survey of patients, whose main goal is to provide an independent system of regular evaluation of patient satisfaction and of hospital quality, as perceived by users of Portuguese NHS hospitals. The second set of indicators is related to the timeliness of care, as measured by the waiting lists for elective surgery. Our analysis suggests that a trade-off between efficiency and quality does not seem to exist here. Therefore, strictly quantitative output specifications tend to provide a complete picture for those units deemed efficient.

To answer the second one, we focus on the perceived patient satisfaction scores. We find that for those units deemed inefficient, abstracting from quality adjustments may lead to the overestimation of their technical efficiency scores.

We conclude that the empirical evidence is not sufficient to identify a clear trade-off between efficiency and quality in the hospitals under review, implying the possibility that efficiency gains may be achieved without a significant sacrifice of service quality. Nevertheless, there is enough evidence to conclude that analyzing hospital efficiency without consideration of differences in quality of service will generate biased results.

When DEA efficiency scores are adjusted for output quality, the decision making units that lie on the technical efficiency frontier remain largely unaltered, even if a great weight is given to quality indicators over quantity indicators of output.

Nevertheless, we find that outside of the frontier adjusting for quality does have an impact in efficiency scores. Our analysis of quality adjusted efficiency scores reveals that, using a Wilcoxon matched pairs test, the median efficiency scores are statistically different at the usual levels of significance.

We conclude that the empirical evidence is not sufficient to identify a clear trade-off between efficiency and quality in the hospitals under review, implying the possibility that efficiency gains may be achieved without a significant sacrifice of service quality. Furthermore, there is enough evidence to conclude that analyzing hospital efficiency without consideration of differences in quality of service will generate biased results.

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